TECHNIQUE AND EQUIPMENT PITFALLS IN SPIROMETRY TESTING: SERIOUS THREATS TO YOUR RESPIRATORY SURVEILLANCE PROGRAM

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OUTLINE

- SPIROMETRY EVALUATION IN THE OCCUPATIONAL SETTING
- DATA LIMITATIONS OF MANY SPIROMETERS
- ERRORS THAT INFLATE TEST RESULTS
- ERRORS THAT REDUCE TEST RESULTS
- EXAMPLES

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SPIROMETRY EVALUATION IN THE OCCUPATIONAL SETTING

1. **Compare one test result with reference value**

   - Above cut-off level required by employer to perform job or wear respirator? **; or
   - Normal or impaired? - periodic medical assessment

** Volumes may be under-recorded, especially for those with large lungs – test may focus on exceeding cut-off. Graphs usually saved – unfortunately may become next year's "baseline."

2. **Examine multiple test results for rate of change over time**

Technical errors cause false positives and negatives for both types of evaluation

DATA LIMITATIONS OF MANY SPIROMETERS

1. Many save only 3 "best" curves (highest sum of FEV1 + FVC); and
2. Most report largest recorded FVC and FEV1, per ATS and OSHA.

So.... Falsely inflated values will be reported, rather than lower accurate values.

3. Often must delete curve so it won't be saved, sometimes with no real-time graph;
4. If saved, often cannot delete curve unless delete test session and start new test.

So.... Need to know that technical errors can <u>inflate</u> results, and Recognize which curves to delete.

ERRORS THAT *INFLATE* TEST RESULTS

1. **Poor testing technique**:

   a) Extra breath through the nose (Figure 1),

   b) Slightly submaximal expiratory effort (negative effort dependence of the FEV1) (Figure 2), and

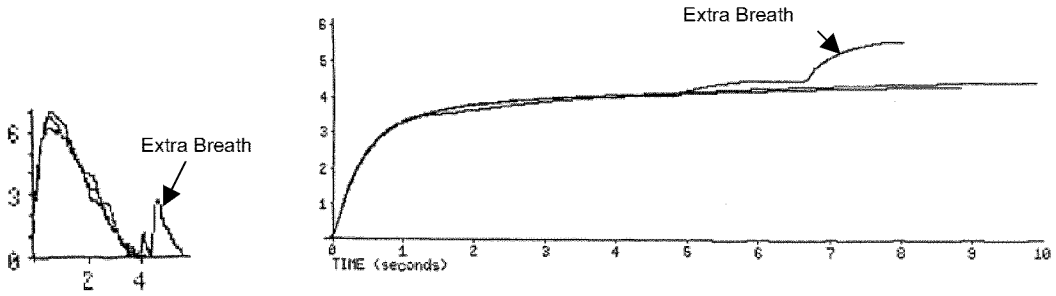
   c) Accept/save curve with large hesitation, even when flagged by spirometer (Figure 3).

2. **Flow-type spirometer malfunctions during subject testing**, *even though calibration successfully set or checked earlier in the day:*

   a) Inaccurate zeroing of sensor, performed before each expiration (Figure 4); or

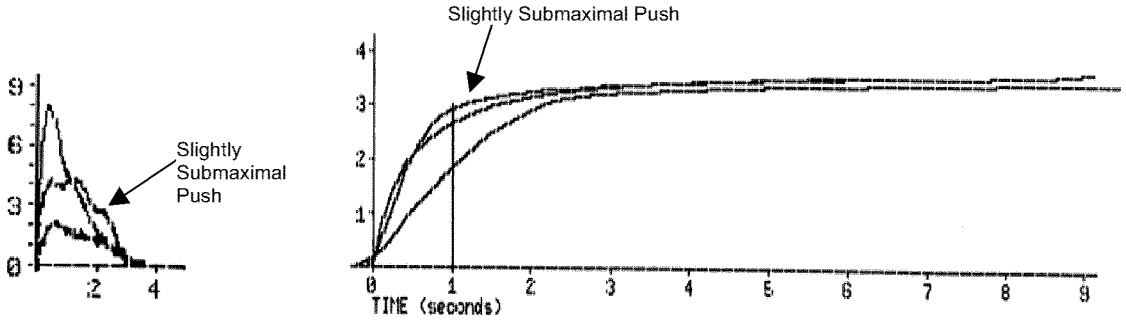
   b) Sensor characteristics change between expirations due to warming, deposition of mucus, or condensation of water vapor (Figure 5).

Figure 1: Extra Breath



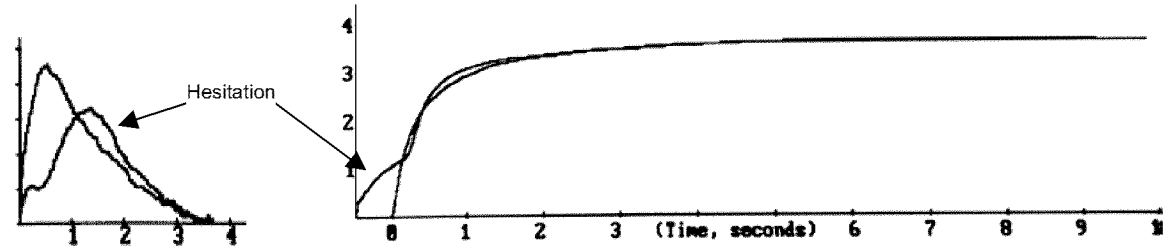
	FVC (L)	% Pred	FEV1/FVC%	% Pred
Good Effort	4.78	96	74	93
Extra Breath	5.96	119	59	75

Figure 2: Slightly Submaximal Expiratory Effort (Negative Effort Dependence of FEV1)



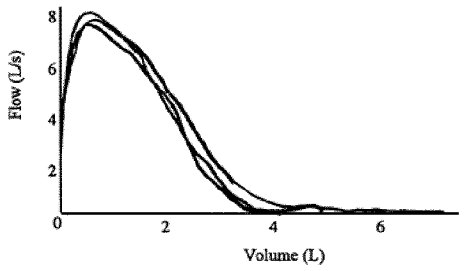
	FEV1	% Pred	FEV1/FVC %	% Pred
Good Effort	2.90	99	74	90
Submax Push	3.13	106	79	96

Figure 3: Excessive Hesitation



	FEV1	% Pred	FEV1/FVC5	% Pred
Good Effort	3.23	109	82	101
Large Hesitation	3.34	112	83	102

Figure 4: Zero Flow Error: Screen Pneumotach



57 yo 68" WM	Obs	Pred	%Pred
Best FVC (L)	7.48	3.67	204%
Best FEV1 (L)	3.52	2.89	122%
FEV1/FVC (%)	47.1	78.8	60%
FVC Reprod = 2.50 L		FEV1 Reprod = 0.19 L	

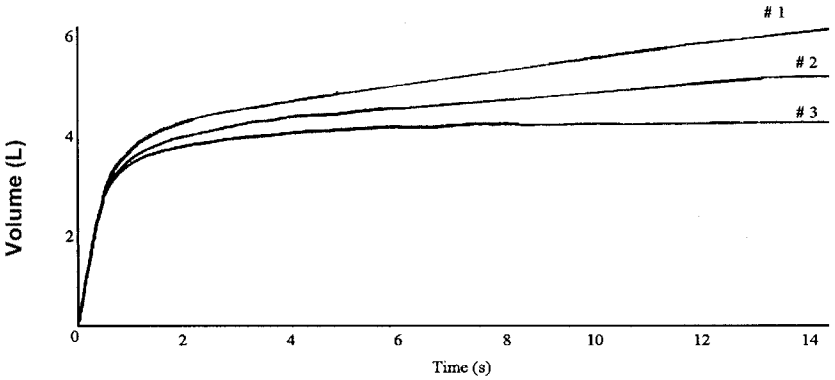
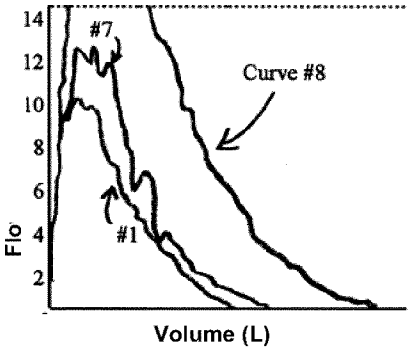
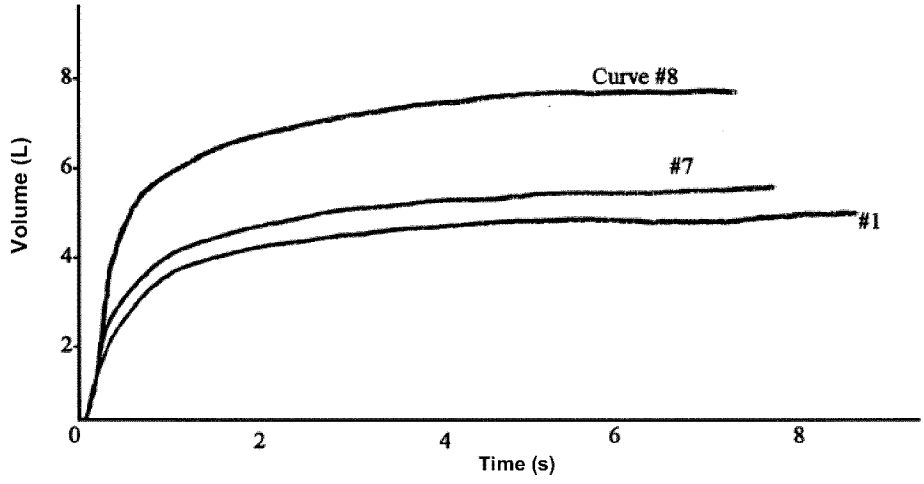


Figure 5: Condensation/ Mucus Deposition: Screen Pneumotach



46 yr 72" WM	Obs	Pred	%Pred
Best FVC (L)	7.59	5.28	144%
Best FEV1 (L)	5.82	4.30	135%
Best PEF (L/s)	15.9	9.59	166%
FEV1/FVC %	76.7	81.1	95%
FVC Reprod	2.29 L		
FEV1 Reprod	1.95 L		
PEF Reprod	3.91 L (25%)		



ERRORS THAT *REDUCE* TEST RESULTS

1. **Leaks in volume spirometer** or breathing tubes:

   a) Reduce FVCs significantly but are *not visible in spirograms* until leak is very large (Figure 6);

   b) Checking for leaks at least daily in the calibration check is essential.

2. **Errors in testing technique** (usually visible in tracing):

   a) Small inspiration (Figure 7-2)
   b) Weak push (Figure 7-3)
   c) Tongue in mouthpiece (Figure 7-4)
   d) Early termination (Figure 7-6)
   e) Glottis Closure (Figure 7-7)

3. If technician corrects test error, reduced values will be replaced by higher, more accurate, results.

Figure 6: Effects of Spirometer Leaks on Test Results

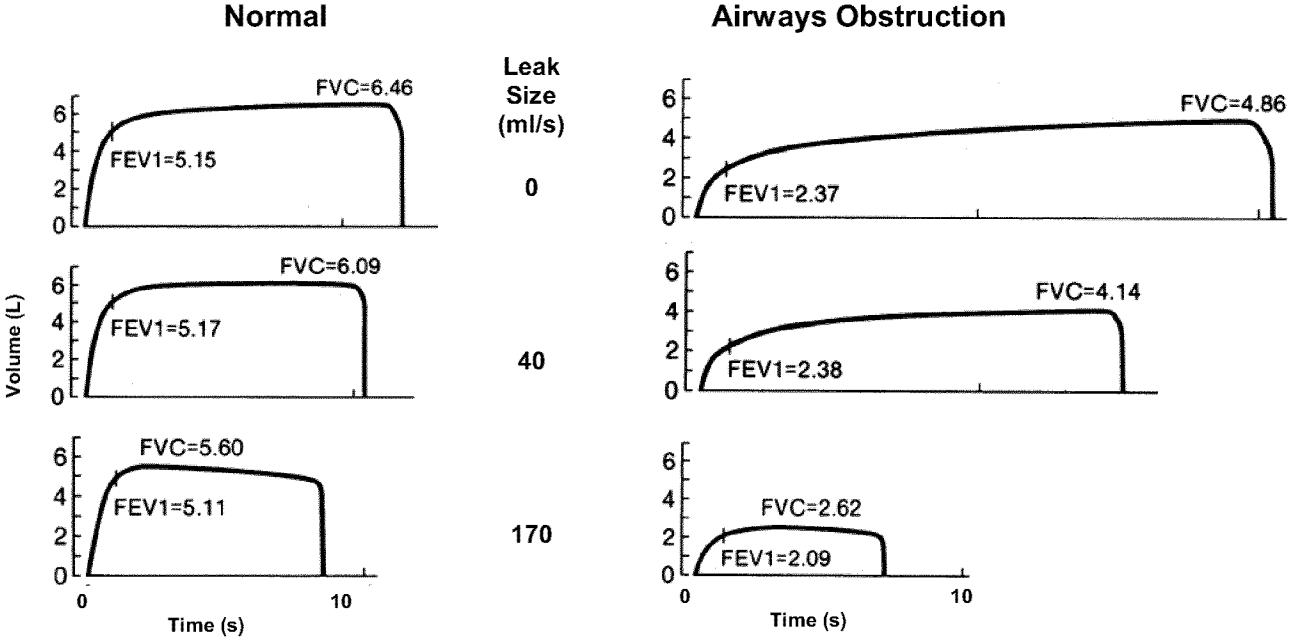
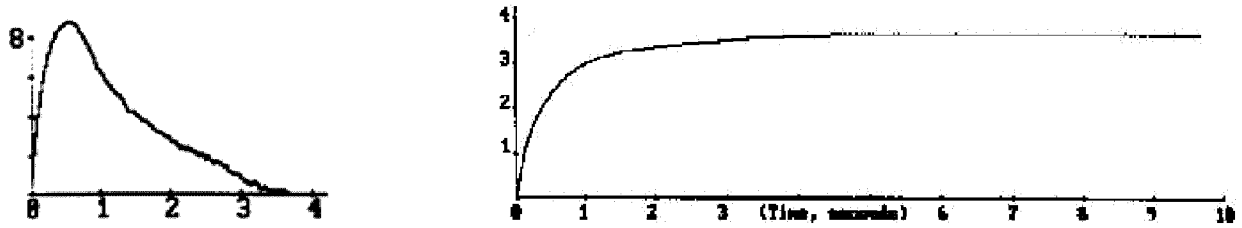
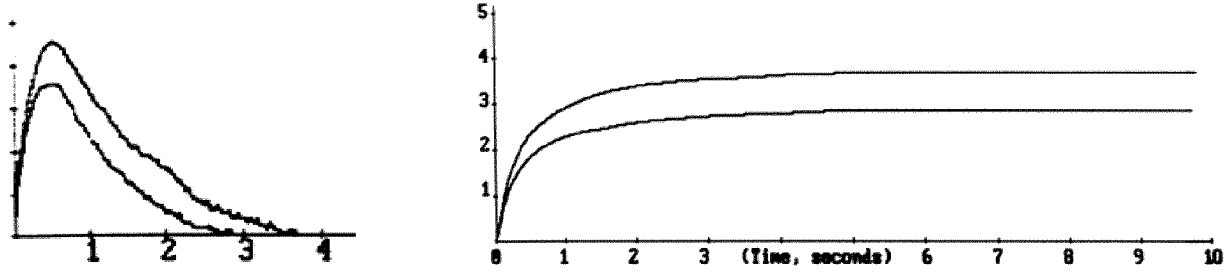


Figure 7-1. GOOD EFFORT



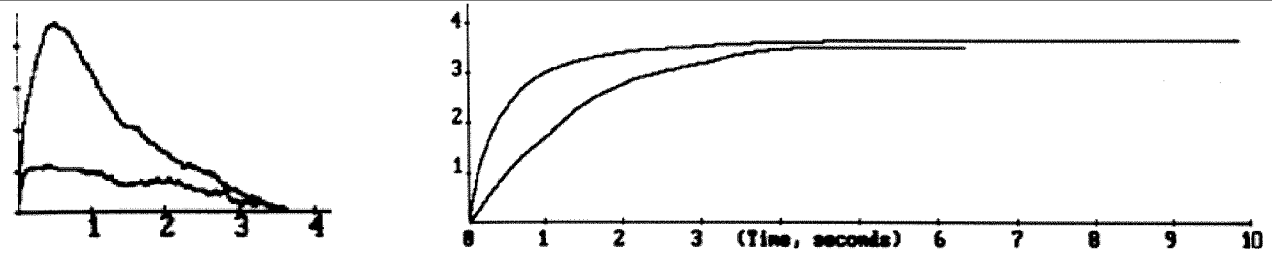
Parameter	Observed	% Pred
FVC (L)	3.93	107
FEV1 (L)	3.23	109
FEV1/FVC, %	82	101

Figure 7-2. SMALL INSPIRATION



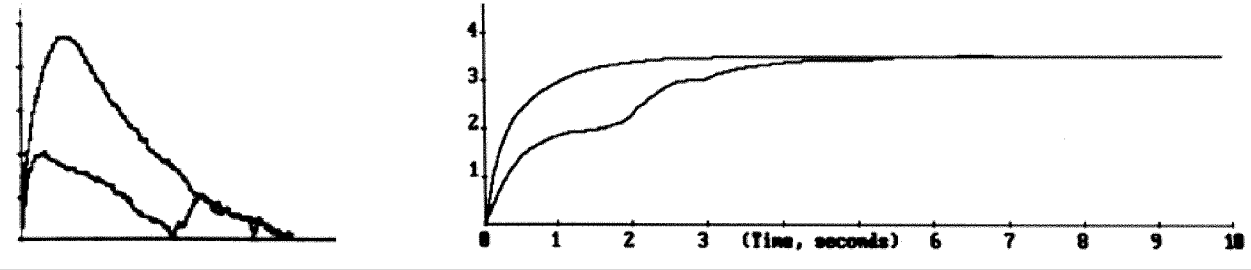
Parameter	Observed	% Pred
FVC (L)	3.11	85
FEV1 (L)	2.48	83
FEV1/FVC, %	80	99

Figure 7-3. WEAK PUSH



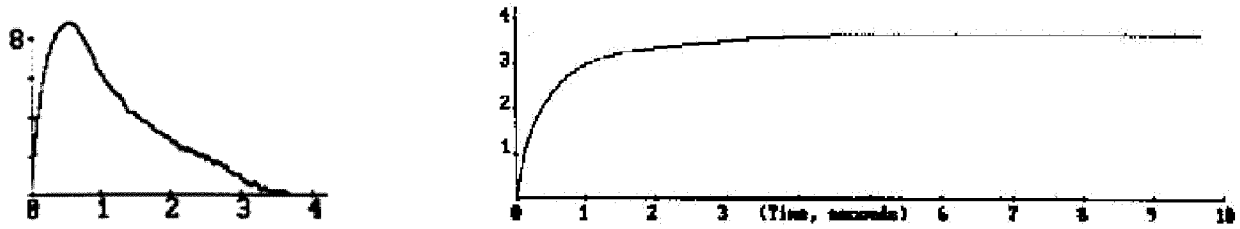
Parameter	Observed	% Pred
FVC (L)	3.83	105
FEV1 (L)	1.86	63
FEV1/FVC, %	49	60

Figure 7-4. TONGUE IN MOUTHPIECE



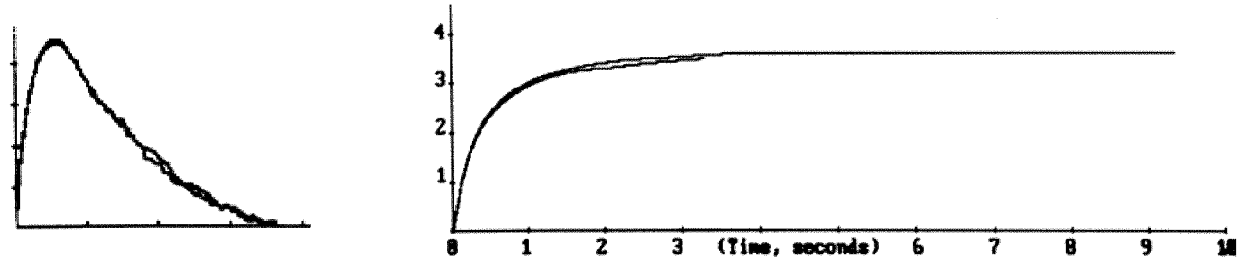
Parameter	Observed	% Pred
FVC (L)	3.85	105
FEV1 (L)	2.02	68
FEV1/FVC, %	52	64

Figure 7-5. GOOD EFFORT



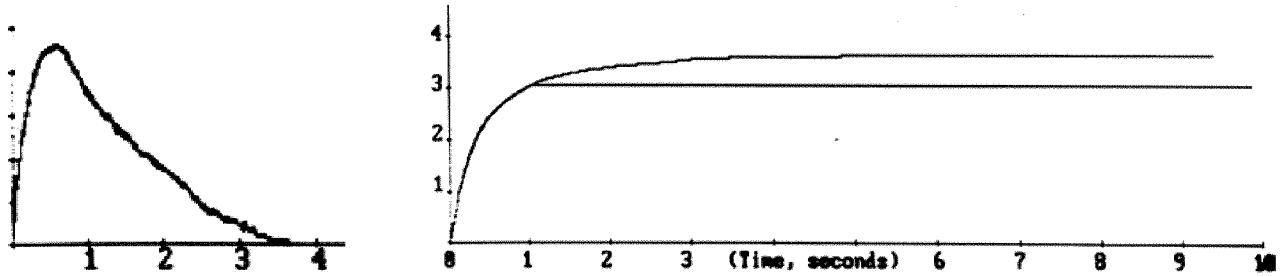
Parameter	Observed	% Pred
FVC (L)	3.93	107
FEV1 (L)	3.23	109
FEV1/FVC, %	82	101

Figure 7-6. EARLY TERMINATION



Parameter	Observed	% Pred
FVC (L)	3.77	103
FEV1 (L)	3.16	106
FEV1/FVC, %	84	104

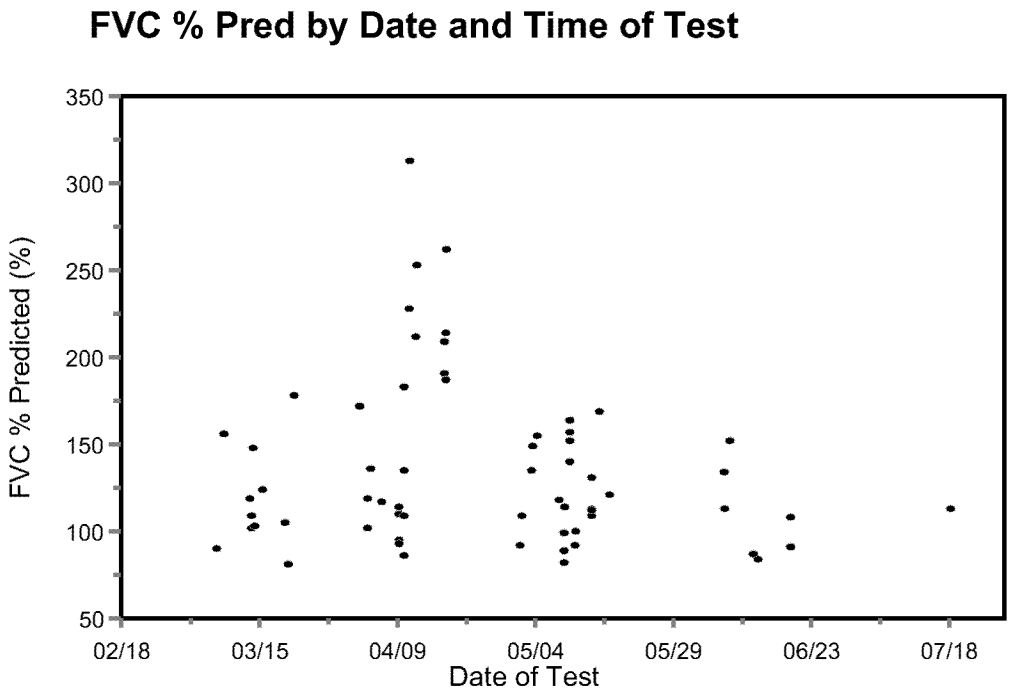
Figure 7-7. GLOTTIS CLOSURE



Parameter	Observed	% Pred
FVC (L)	3.31	90
FEV1 (L)	3.27	110
FEV1/FVC, %	99	122

Example 1: Failure of Medical Screening for Respirator Use

- Spirometries conducted on 62 employees in a manufacturing plant.
- Employees were aged 20 - 62, median = 41.6 yr, 63% current smokers, 84 % male.
- 50% of employees tested had both FEV1 and FVC > 120 % of Predicted.
- Spirometer was frequently calibrated, plot of FVC % predicted shown below. Some probable zero flow errors, some possible moisture condensation; spirometer not holding its calibration.
- Test results are uninformative.



Example 2: Failure of a Medical Surveillance Program

Management Summary Report
Employee Spirometry Testing
12/31/99

Employees receiving annual spirometry test	31	(100%)
• Annual PFT values in normal range	5	(15%)
• Annual PFT values abnormal	1	(3%)
• Annual test FVC or FEV1 decreased more than 15% in past year	20	(65%)